Introduction and Application of Synthetic Biology

合成生物學之介紹與應用

About iGem

International Genetically Engineered Machine (iGEM) Competition is a prestigious competition of synthetic biology all over the world, with over 200 institutions from more than 30 countries taking part in this competition. One of the expectations of the competition is to increase the awareness of the general public towards synthetic biology. Thus, human practice is a crucial element throughout the competition. The University of Hong Kong has been joining the competition since 2009 and we have won 1 gold and 4 silver medals in the past.

HKU 2015 iGEM Team

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HKU iGEM Team 2015

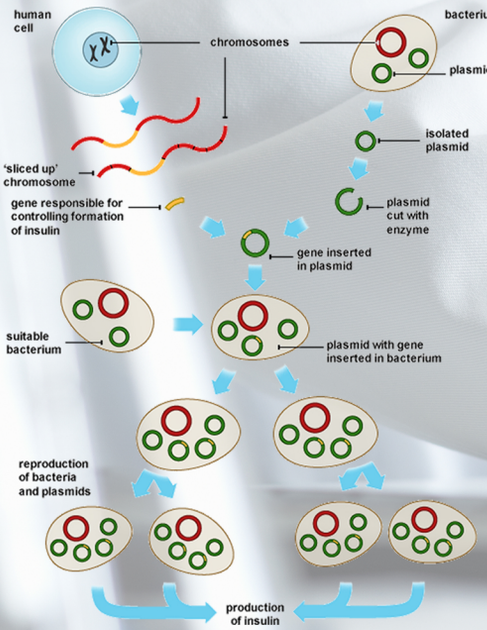
About Synthetic Biology

Basic Introduction

Synthetic biology is a hot topic in the study of biological science nowadays. It combines knowledge and tools from different academic fields. Having understood more about genes, scientists are able to improve or even design the function of a cell.

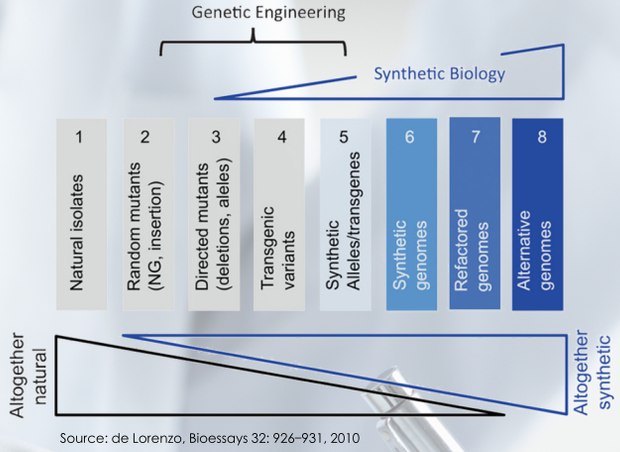
A genome is an entire set of genes. It is composed of four different nucleotides from DNA, i.e. Adenine (A), Thymine (T), Guanine (G) and Cytosine (C). Different combinations and permutations of sequences of nucleotides will generate different proteins, allowing the cells to perform different functions. The fundamental biological blocks to "build" a living organism include promoter, ribosome binding site (RBS), transcription terminator, etc. These "building blocks" are believed to control behavior of the genes. Therefore, apart from producing a complete genomic structure, synthetic biologists also start to insert different engineered machineries into the gene to enrich its function.

In order to change the targeted sequence of the genome, we need to know the DNA sequence beforehand. Cloning (or subcloning) and polymerase chain reaction (PCR) enable scientists to analyze the sequence of the target DNA. After that, gene splicing is required for the addition or modification of the gene function. Like cut-and-paste, restriction enzyme can cut the DNA-to-be-modified from the plasmid. Then, we can insert the gene with preferable function back to the plasmid to replace the previous DNA fragment by sticky-end ligation.



Source: http://sgugenetics.pbworks.com/

Take the production of insulin as an example. In the beginning, scientists look for the gene responsible for the generation of insulin inside one's body from the human genome database and, that gene will be cut out by restriction enzyme. Then, scientists will obtain the plasmid, a small self-replicating DNA molecule, from a bacterium. An identical cutting site, also known as restriction site, on the plasmid will then be obtained by the same restriction enzyme as the one used for cutting out insulin gene. After that, the insulin gene will be inserted and stuck to the restriction site of the plasmid by DNA ligase. As a result, the bacterium will carry insulin gene and it will have insulin-synthesis property. Under further plasmid replication and cell division, insulin can be manufactured to a large amount. Comparing to the traditional insulin collection from pigs, this method is known to be costless and the adverse effects have been reduced vigorously.



Source: de Lorenzo, Bioessays 32: 926–931, 2010

Synthetic biology is the collaboration between different fields, including systems biology, genetic engineering, mechanical engineering, physics and computer science. Synthetic biology aims to synthesise biologically based systems which perform functions that have never existed before. Scientists believe that synthetic biology is the key to many major challengers of the future.

Moral and Ethics in synthetic biology

Synthetic biology allows us to create new biological systems that can potentially yield benefits on a global scale. However there are concerns over such technology.

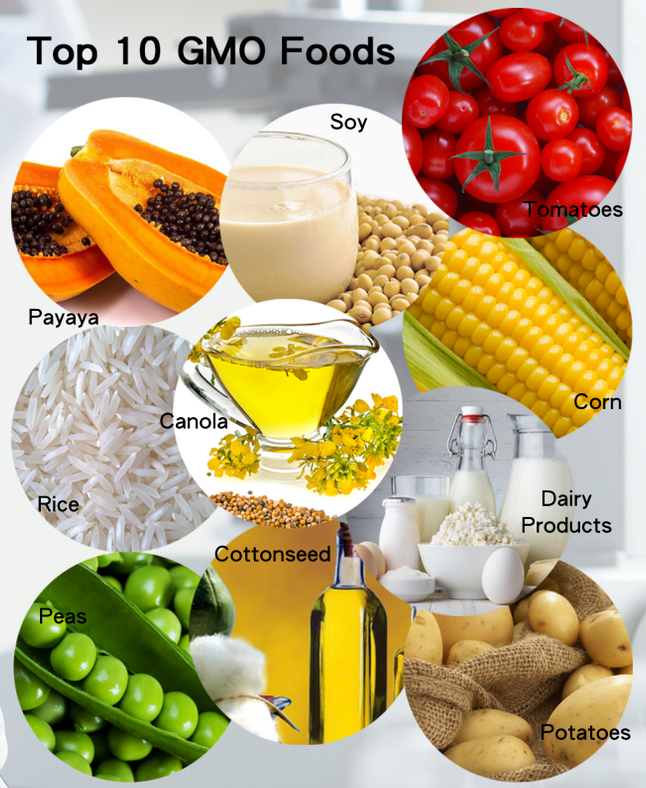
Since synthetic biology is mostly based on creation, there could be economic competition and even exploitations of parties that carries natural systems given by the nature. Also the new systems created may pose threats to public health or to the environment as the synthetic systems or organisms created may to invasive.

Application of Synthetic Biology

Synthetic DNA and life

Due to the cost reduction of nucleotides, the basic building materials of DNA, DNA construction has been extended to the genome level. Synthetic DNA refers to the rearrangement of nucleotides, addition or deletion of specific genes so as to give the organism specific properties.

Genetically modified food is an example of synthetic biology. Scientists believe that there is a gene which corresponds to cold-resistance, in some polar fish. They extract the desired cold-resistant gene and inserted it into the genome of tomatoes to make them become more cold-resistant in order to increase the yield. Many other crops of high demand had been engineered for resistance to pathogens and herbicides and for better nutrient profiles.



Synthetic life is an important topic in synthetic biology. Synthetic life has three main goals. First, to understand life through building one instead of dismantling it. Second, to make use of genetically modified engineering to build a more mature systems to improve current technologies. Third, to expand boundaries of life and mechanics to produce programmable organisms.